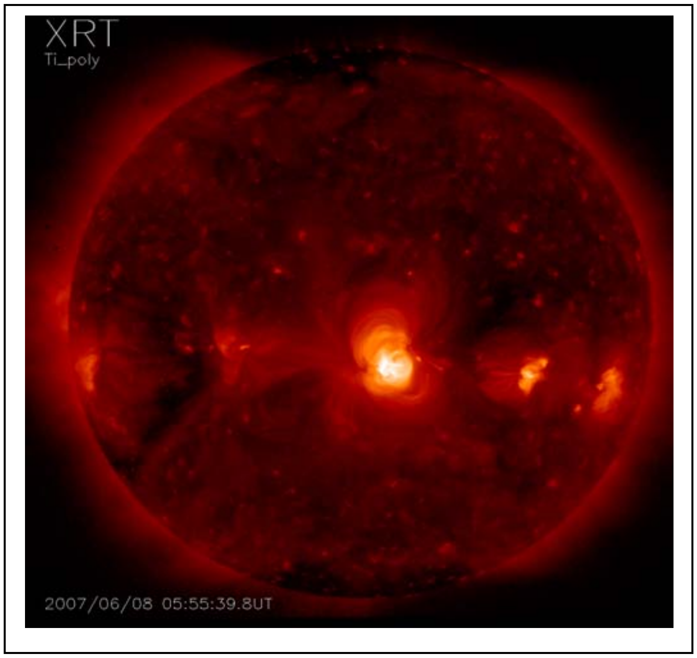
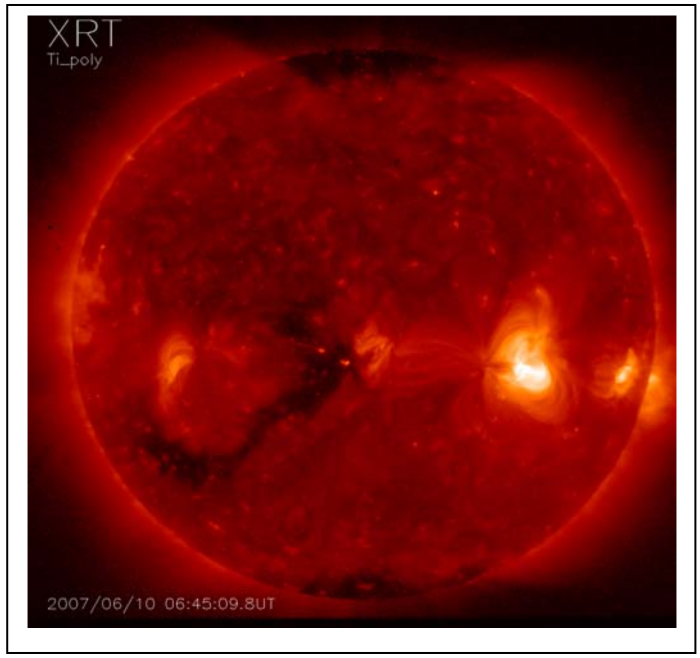
How fast does the sun spin?





The sun, like many other celestial bodies, spins around on an axis that passes through its center. The rotation of the sun, together with the turbulent motion of the sun's outer surface, work together to create magnetic forces. These forces give rise to sunspots, prominences, solar flares and ejections of matter from the solar surface.

Astronomers can study the rotation of stars in the sky by using an instrument called a spectroscope. What they have discovered is that the speed of a star's rotation depends on its age and its mass. Young stars rotate faster than old stars, and massive stars tend to rotate faster than low-mass stars. Large stars like supergiants, rotate hardly at all because they are so enormous they reach almost to the orbit of Jupiter. On the other hand, very compact neutron stars rotate 30 times each second and are only 40 kilometers across.

Rotation is a complicated phenomenon in astrophysics. In most cases, the rotation speed of a star as it ages has to do with a principal called the Conservation of Angular Momentum. If a star doubles in its physical size, its rotation speed drops by a factor of two so that none of its angular momentum is lost. This usually happens as a star evolves to become a giant or supergiant star towards the end of its life. On the other hand, very young stars nearly the size of the sun at birth, slow down because of magnetic braking, much like a car slows down by friction applied by its metal breaks.

The X-ray telescope on the Hinode satellite creates movies of the rotating sun, and makes it easy to see this motion. A sequence of these images is shown on the left taken on June 8, 2007 (Left); June 10 2007 (Right) at around 06:00 UT.

The radius of the sun is 696,000 kilometers.

Problem 1 - Using the information provided in the images, calculate the speed of the sun's rotation in kilometers/sec and in miles/hour.

Problem 2 – About how many days does it take to rotate once at the equator?

Inquiry Question: What geometric factor produces the largest uncertainty in your estimate, and can you come up with a method to minimize it to get a more accurate rotation period?

Answer Key:

1) Using the information provided in the images, calculate the speed of the sun's rotation in kilometers/sec and in miles/hour.

First, from the diameter of the sun's disk, calculate the image scale of each picture in kilometers per millimeter.

Diameter= 76 mm. so radius = 38 mm. Scale = (696,000 km)/38 mm = 18,400 km/mm

Then, find the center of the sun disk, and using this as a reference, place the millimeter ruler parallel to the sun's equator, measure the distance to the very bright 'active region' to the right of the center in each picture. Convert the millimeter measure into kilometers using the image scale.

Picture 1: June 8 distance = 4 mm d = 4 mm (18,400 km/mm) = 74,000 km
Picture 2; June 10 distance = 22 mm d = 22 mm (18,400 km/mm) = 404,000 km

Calculate the average distance traveled between June 8 and June 10.

Distance = (404,000 - 74,000) = 330,000 km

Divide this distance by the number of elapsed days (2 days)…………….. 165,000 km/day

Convert this to kilometers per hour………………………………………….. 6,875 km/hour

Convert this to kilometers per second……………………………………….. 1.9 km/sec

Convert this to miles per hour ………………………………………………… 4,400 miles/hour

Problem 2 – About how many days does it take to rotate once at the equator?

The circumference of the sun is 2 π (696,000 km) = 4,400,000 kilometers.

The equatorial speed is 66,000 km/day so the number of days equals 4,400,000/165,000 = **26.6 days.**

Inquiry Question:
Because the sun is a sphere, measuring the distance of the spot from the center of the sun on June 10 gives a distorted linear measure due to foreshortening.

The sun has rotated about 20 degrees during the 2 days, so that means a full rotation would take about (365/20) x 2 days = 36.5 days which is close to the equatorial speed of the sun of 35 days.